

# India's Silent Valley and Its Threatened Rain-forest Ecosystems

by

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## INTRODUCTION

The depletion of the tropical rain-forests of the world at an estimated rate of 245,000 km<sup>2</sup> per year (Myers, 1980) is one of the most disturbing aspects of present-day biospherical tendencies. For, although occupying less than 10% of the Earth's land surface, they harbour about half of the Earth's 5–10 million biological species (Hek-sira, 1981), while Woodwell *et al.* (1978) have estimated a net release of 4–8 petagrams (each of 10<sup>15</sup> g) of carbon annually into the atmosphere, mainly from the clearing and/or burning of tropical forests.

In India the rain-forests were formerly distributed in a portion of the south-west region and in the foothills of the north-east region. While most of their areas have already been put to other land-uses in the latter region, in the south-west (the Western Ghats), in and around Silent Valley, even today almost virgin tracts of tropical rain-forest are left. In recent years the proposal to construct a reservoir in Silent Valley by damming the River Kunthipuzha—to generate hydroelectric power and to irrigate fields of crops—raised several controversies, including (i) whether or not the Silent Valley forest represents a typical tropical rain-forest, and (ii) whether the reservoir construction would be detrimental to the forest. The first question is being addressed by Singh *et al.* (in press).

The Government of India has not, so far, allowed the development of the proposed reservoir. However, in view of the power needs, the supporters of the dam-construction proposal continue to raise their voices, the controversy is still alive, and the Silent Valley forest remains threatened (cf. Oza, 1981; Ramakrishnan, 1984).

In this paper, a brief description of the vegetation of the Silent Valley is given, and the need for conservation of this system is discussed. A plea is made for according in the status at least of a Biosphere Reserve.

## THE SILENT VALLEY

### *Physical and Biotic Set-up*

The Silent Valley reserve forest, spread over about 9,000 ha, is located on the lower side of the Nilgiri plateau, which ranges in elevation from about 500 to nearly 2,000 m (Fig. 1). From the climatological account given by Lengerke (1977) for Nilgiri and environs, the annual rainfall in the Silent Valley area would appear to centre around 5,000 mm, with minimum temperature ranging between 8°C and 14°C, and maximum between 23°C and 29°C.

The valley has been bereft of human settlement during recorded history, the current human interferences being in the form of selective tree-felling by the Kerala State Forest Department, burning of adjacent savanna and forest edges, and pre-dam construction work. The forest is drained by the River Kunthipuzha and its tributaries (Fig. 1).

The vegetation is riparian on both sides of the River and its tributaries. On the upland, along the hill-slopes, the tall trees with clear boles impart an appearance (Figs 2 and 3) which is distinct from that of the riparian forest (Fig. 4). In their water-relations, at least as far as could be judged from the visual appearance of the forest floor, the Silent Valley upland forest is called here mesic upland forest, while that of the adjacent Attapadi

reserve is called 'less-mesic upland forest'. Recurrent burning especially of the latter has led to the formation of savanna, with few scattered fire-resistant trees on certain ridge-tops and slopes (Fig. 5).

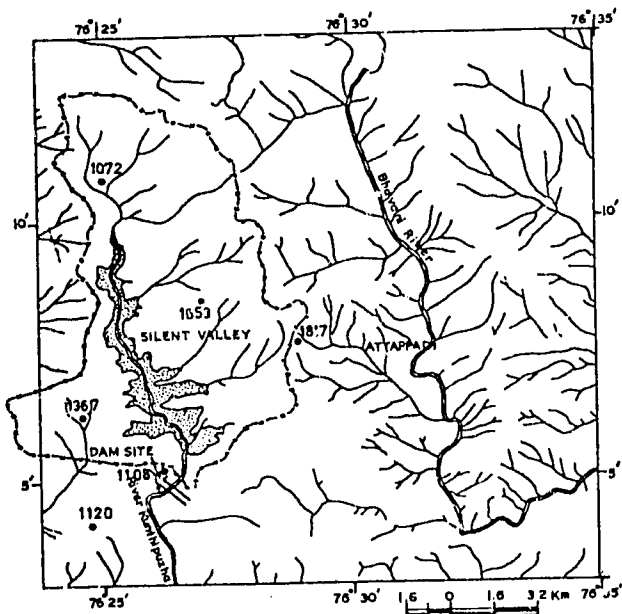


FIG. 1. Sketch-map of Silent Valley (delimited by line broken by crosses) and the adjoining Attappadi (sic) region, with indication of the proposed dam and reservoir (dotted area).

### Salient Features of Vegetation

Details of the vegetation of Silent Valley are given in Singh *et al.* (in press), its main feature being that the forests represent types of tropical rain-forest. The upland forests are characterized by: their multilayered (5-6 layers, cf. Fig. 6) structure (Table I), with emergent species raising their crowns above the general canopy layer and imparting, in consequence, an undulating or 'bumpy' look to the canopy surface (Fig. 3); their copious growth of fine feeder-roots, characteristically rising up to the soil's surface and occupying the interface of the decaying litter layer and the mineral matrix of the soil; their tallest 'emergent' trees growing up to around



FIG. 2. The Silent Valley forest, an overview. Photo: Dr N.C. Nair.



FIG. 3. A general view of upland forest in Silent Valley. The foreground represents 'creeping' deforestation. Photo: Dr V.M. Meher-Homji.



FIG. 4. Barks of the River Kunthipuzha showing the gallery forest and trees with smooth bark. Photo: Dr N.C. Nair.



FIG. 5. Grassland with sparse tree vegetation. Photo: Dr N.C. Nair.

50–60 m (Fig. 6), with typically slender and clear boles often buttressed at the base (Fig. 7), and light-coloured bark having a thickness in some 50% of the species of less than 3 mm (Table II); and the prevalence of woody species even in the ground flora, where the shrubs grow typically like trees, with unbranched stems bearing a crown at the top (treelet).

Other features are that the leaves are typically of the laurel type, with the size increasing from the uppermost to the lowest tree layer (Table II); the abundance of epiphytes, stranglers, and woody climbers (lianas); the typically evergreen appearance even in spring, when leaf-fall is prevalent in most parts of India; the species-richness on the higher side (Table I) of the range given for tropical rain-forests of the world; and the establishment of a situation in which the most important tree species varies from one size-class to another (Table III).

Compared with the upland forests, the riparian forest has a different physiognomy and species-composition (Fig. 8 and Tables III and IV). The trees tend to be shorter, with less-slender boles and the crown's depth markedly greater than in upland forest trees. Furthermore, the surface root-system is less developed.

The relatively large total tree-basal cover (Table I) of the mesic upland forest (102.7 m<sup>2</sup> per ha compared with 35.0–73.6 m<sup>2</sup> per ha reported for other tropical forests)

TABLE I  
Certain Community Characters of the Forests within and around Silent Valley.

	Riparian	Mesic upland	Less-mesic upland
Average height of the tallest layer (m)	34.9	54.6	42.0
Number of layers	5	6	5
Total basal area of tree-trunks (m <sup>2</sup> per ha)	47.7	102.7	29.7
Species' richness			
1. Number of species measured per 0.1 ha for the riparian and less mesic upland forests, and per 0.03 ha for the mesic upland forest.	36	34	27
2. Number of species extrapolated per 0.4 ha.	56	84	44
Shannon-Wiener Index*			
Trees	4.15	4.08	3.52
Shrubs	1.18	2.23	0.90
Climbers	2.93	2.57	3.02

$$* \text{Shannon-Wiener Index} = -\sum_{i=1}^S (N_i/N) \log_2 (N_i/N), \text{ where}$$

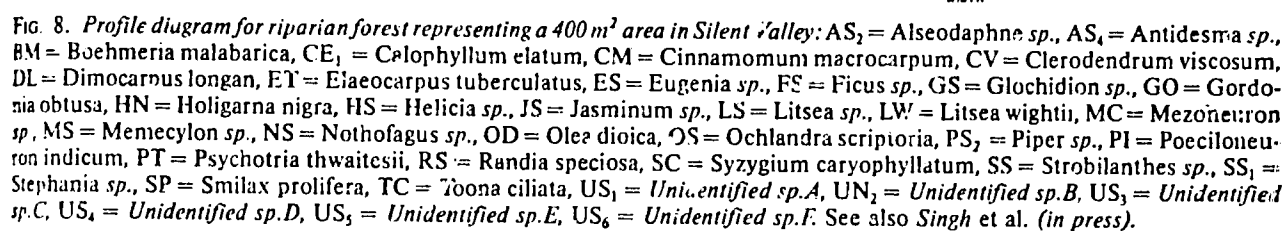
$N_i$  is the total number of individuals of species  $i$ , and  $N$  is the total number of individuals of all species.  $S$  = total number of species. The Index was calculated separately for tree species, shrub species, and climbers. The higher the values of the Index are, the higher will be the species' diversity.

indicates its luxuriance, and suggests that the forest has been free from marked biotic pressure. The proportion of species in Silent Valley with bark thickness 3 mm or less was remarkably high (56%) (Table II), suggesting that favourable growth-conditions prevail throughout the year.

Analysis of the vegetation suggests that the present forests represent essentially the mixed types of tropical rain-forest, where dominance exhibited by any single species is very low, in contrast to some rain-forests with single dominant species as described by Richards (1952), where a particular species may form 52.5–57% of the tree population. Richards is of the opinion that rain-forests with single-species dominance develop where conditions are relatively unfavourable.

The population structure of the two most important species of the upland mesic forest, namely *Palaquium ellipticum* and *Cullenia exarillata*, indicated a stable population when individuals of the entire forest area were accounted for, but an unstable population when only a small area (800 m<sup>2</sup>) was considered (Singh *et al.*, in press). Obviously, a larger area than this latter is required to maintain their population. It is evident that, in order to maintain a stable population of relatively rare large-tree species in a tropical rain-forest, an area larger than that of the Silent Valley forest may be required.





*Important Species (with IVI >44) for Each Girth-class in Different Forests of Silent Valley.* (The Importance Value Index (IVI) is the sum of relative frequency, relative density, and relative basal area. All values are for trees  $\geq 31.5$  cm cbh.)

Girih-class (cm)	Riparian	Mesic upland	Less mesic upland
31.5 to 65.5	<i>Clerodendrum viscosum</i>	<i>Palaquium ellipticum</i>	<i>Agrostistachys meeboldii</i>
66 to 100	<i>Pociloneuron indicum</i>	<i>Palaquium ellipticum</i>	<i>Eugenia</i> sp.
100.5 to 134.5	<i>Elaeocarpus tuberculatus</i>	<i>Alseodaphne</i> sp.	—
135 to 169	<i>Cinnamomum macrocarpum</i>	<i>Holigarna nigra</i>	Unidentified sp.
169.5 to 203.5	—	<i>Drypetes elata</i>	<i>Drypetes elata</i>
204 to 233	<i>Olea dioeca</i>	<i>Drypetes elata</i>	<i>Cullenia exarillata</i>
238.5 to 272.5	<i>Elaeocarpus tuberculatus</i>	—	<i>Cullenia exarillata</i>
≥273	—	—	<i>Palaquium ellipticum</i>

*Importance Value Index (IVI) of Dominant Species.* (All values are for trees  $\geq 31.5$  cm cbh.)

Riparian		Mesic upland		Less-mesic upland	
Species	IVI	Species	IVI	Species	IVI
<i>Elaeocarpus tuberculatus</i>	40	<i>Eugenia</i> sp.	22	<i>Alseodaphne</i> sp.	38
<i>Eugenia</i> sp.	28	<i>Ficus</i> sp.	30	<i>Palaquium ellipticum</i>	62
<i>Pociloneuron indicum</i>	25	<i>Palaquium ellipticum</i>	64	<i>Drypetes elata</i>	38
<i>Olea dioica</i>	24	<i>Cullenia exarillata</i>	30	<i>Amoora</i> sp.	27
<i>Trona ciliata</i>	20	<i>Drypetes elata</i>	20	<i>Holigarna nigra</i>	14
<i>Clerodendrum viscosum</i>	18	<i>Nothapodytes foetida</i>	18	<i>Litsea</i> sp.	13
Rest: 14 species	145	Rest: 17 species	116	Rest: 13 species	108



FIG. 9. Secondary vegetation with young *Clerodendrum* plants abundant in the 'field-layer' of disturbed forest. Photo: Dr N.C. Nair.

#### NEED TO CONSERVE

The rate of depletion of the tropical rain-forests in most of their areas is alarmingly high, and is such that, if it continued at the present rate, by the end of this century only a few tracts of the unimpaired original forests would be left. More often than not, the immediate economic gains from the exploitation of these forests cause long-term losses in the form of soil erosion, diseases, and pollution (Heksira, 1981; Herrera *et al.*, 1981).

It is consequently quite crucial to decide whether we are going to convert 60 million years of evolution into tissues of wrapping-paper, wood-pulp, veneers, or materials for construction (or a few hundred megawatts of electricity in the case of the Silent Valley), for which there are usually many alternatives available (Heksira, 1981). Or are these unique ecosystems to be preserved, with Mankind and Nature benefiting in many ways including preservation of the large genetic resources lying in them? The 'World Charter for Nature' (similar to the United Nations' Charter of Human Rights), which was passed by the United Nations General Assembly on 28 October 1982\*, emphasized in effect that: (i) special pro-

tection shall be given to unique areas, representative samples of all ecosystems, and habitats of endangered species, and (ii) continued existence of all forms of life shall not be compromised, while the population levels of all species must be at least sufficient for their survival (see Heksira, 1981).

In view of the above, a need to conserve the Silent Valley forest, which is among the few pristine tropical rain-forests left on Earth, is urgent. Some of the possible effects of dam construction and the related impacts on this system will now be discussed.

#### LIKELY DIRECT EFFECTS

A direct effect of the construction of the dam would be the loss of 530 ha of species-rich rain-forest in addition to 300 ha of the savanna, consequent on flooding. The forested area to be submerged, which includes both the riparian (or gallery) and upland forests, accounts for about 6% of the total Silent Valley forest reserve (8,952 ha).

Reservoir construction would alter the ground-water patterns around the resultant lake's shoreline. Normally, the indigenous species adapted to river-bank conditions would do less well along reservoir shores than river-bank ones, owing to more static conditions or irregularity<sup>†</sup> of water-level of the reservoir (Dasmann *et al.*, 1974). Even if shoreline vegetation in the latter instance were to be somewhat similar to the vegetation developed along a stream, it would be structurally simpler. Concomitantly, the faunal diversity, especially of birds, would be lower, as it is related to the number of strata and the height of vegetation (MacArthur & MacArthur, 1961; Whittaker, 1975). In such habitats as fields and marshes, which are structurally simpler, the opportunities for within-habitat specializations are limited, at least for birds (Cody, 1968).

Problems of spread of diseases consequent on construction of dams in the tropics have been highlighted by Dasmann *et al.* (1974). The construction of irrigation works and creation of shorelines have helped to spread malaria in many tropical areas (see, for example, Farver & Milton, 1972).

Inundation also changes the mineral regime of ecosystems. Studies in Panama, for instance, indicated increased mineral storage in the vegetation, due to inundation of the stand, so that the riverine forest contained larger quantities of selected elements than the adjacent upland forests (Farnworth & Golley, 1974). Further problems may come from downstream alteration of the water regime, loss of soil nutrients from seasonal flooding, channel and delta erosion, and increased water-borne diseases (see Farver & Milton, 1972). Areas downstream from a dam may contain systems that are adapted to periodic flooding and particularly to nutrient inputs through silt deposition; completion of the dam

\*Noted as 'Adopted by the UN General Assembly on 28 October 1982' and published in *Environmental Conservation*, vol. 10, No. 1, pp. 67-8, 1983.—Ed.

<sup>†</sup>In answer to our query about this, Dr J.S. Singh replied (in litt. 27 August 1984) 'The water-level is irregular because it depends upon the year-to-year variability in rainfall and water use for irrigation.'—Ed.

may alter the regime unfavourably for the species in such systems. This may also affect the downstream fish populations (Dasmann *et al.*, 1974).<sup>11</sup>

The dam construction at the proposed location would enhance the state of erosion within the submerged and in the adjoining areas owing to accelerated supply of debris and silt from the northern slopes. This apprehension is strengthened by the higher drainage-density on northern slopes than on southern ones. (O.P. Goel, pers. commun.), inducing a high rate of erosion on the northern slopes of the basin, thus bringing lots of silt to the lower reaches of the basin. The past records (Gadgil, 1979) indicate that the rate of siltation in 17 reservoirs of India has exceeded the expected rate, thus reducing the useful life of the reservoirs considerably.

#### INDIRECT EFFECTS

It is estimated that a population of 3,000 workers would be involved in the construction work of the proposed dam for a period of about seven years. Considering the average size of the family to be of at least three individuals (each worker is assumed to be accompanied with his/her spouse and, on average, at least one child), the effective population size might well amount to 9,000. At the fire-wood consumption-rate of 0.8 kg *per caput* per day (Khadi and Village Industries Commission, 1975), the total fuel-wood consumption during seven years would be 18,396 tonnes.

Our observations have indicated that the most common girth-class exploited for fire-wood was 30–60 cm, and that the preference for cutting a tree for fuel was not species-specific. Assuming that  $2.2 \times 10^9$  m<sup>3</sup> wood-volume converts to about  $2 \times 10^9$  tonnes of the above-ground dry matter in the cut-down trees (Whittaker & Likens, 1975), and the volume available in the 30–60 cm girth-class equals 20.5 m<sup>3</sup> per ha (computed from Chandrashekharan, 1973), from each hectare of the forest usable fire-wood available in terms of dry-weight would be 18.67 tonnes. Thus to extract 18,396 tonnes of the fire-wood, the labour population alone would exploit some 985.3 ha of the species-rich forest which, with the complete loss of a further 530 ha from impoundment (*see above*), would account for about one-sixth of the total area of the Silent Valley reserve forest without counting other effects!

We assume that the timber required for construction of huts for the workers would be met from the area to be submerged, or from areas to be clear-felled for various other purposes. But even if a portion of the projected fire-wood requirement were met from the submersible area, a considerable tract of the more accessible nonsubmersible forest with gentler slopes would be bound to be affected. As pointed out by Gadgil (1979) for the reservoirs of the upper Nilgiri plateau (located in nearby areas), the level of forest exploitation in such an activity is much larger than that reflected by the mere fire-wood extraction.

Interestingly, timber exploitation in tropical rain-forests may be limited to only a few species. For example, in Amazonia only 50 out of many thousands of species are exploited. Future botanical composition is thus affected, sometimes quite drastically—for example, with removal of dominants and damage in such selective felling. Indeed, such removal of large trees often damages the remaining ones beyond recovery, and far more than would be the case in a temperate forest.

The hydroelectric and irrigation projects would open up previously inaccessible regions that are rich in wildlife to new agricultural settlers and poachers (*cf.* Gadgil, 1979, who also reports that the colonization of areas rendered accessible by the Silent Valley hydroelectric project is already underway, and will lead to irreversible damage). These settlers may follow the pattern of those in the Idikki area (another project in the Western Ghats), who have already colonized the hill-slopes that are unfit for cultivation, while large stretches of the nearby Attapadi area are mute witness to this effect.

Forest openings, irregularly distributed in space and time, would be created by the firewood and timber extraction. Although the creation of small gaps, due to frequent natural tree-fall and subsequent regeneration, (Figs 10 and 11), is an essential part of a dynamic tropical



Fig. 10. A group of saplings of *Canarium strictum* growing in gap left by fallen tree. Photo: Dr V.M. Meher-Homji.

<sup>11</sup>These and many allied problems are well treated by Dr Geoffrey E. Petts in his book, *Impounded Rivers*, which will be published shortly in our Environmental Monographs & Symposia series by John Wiley & Sons.—Ed.



FIG. 11. The background of Fig. 10 shows a sizeable area exposed through natural death of trees. Photo: Dr V.M. Meher-Homji.

rain-forest (Hartshorn, 1978), creation of large gaps and concomitant changes in microenvironment leads to the development of a vegetation dominated by pioneers (e.g. *Macaranga peltata* and *Clerodendrum* sp. in Silent Valley, Fig. 9).

With continued disturbance, as still larger and larger gaps are created in such a forest, Kramer (1926, 1933) believes that conditions become so unfavourable for forest trees that they fail to reestablish themselves for a very long time. Indeed, regeneration of humid tropical forests, when once destroyed, may be extremely slow or even never occur (Farnworth & Golley, 1974). Ng (1980) has shown, on the basis of seed germination of 335 species of Malaysian woody flora, that the time-lapse at which 50% of the species are withdrawn from the seed-bank in soil is only six weeks. Obviously, the soil is virtually useless as a source of seeds for the establishment of the original forest composition. Indeed, the tropical rain-forests are a non-renewable resource *par excellence*.

Ng (1983) has also shown that rain-forests which regenerate after exploitation are not likely to achieve the height of the original forest, because the lowered vegetational matrix will lower the clear-bole-height (i.e. to which trunks remain branchless) of developing young trees. Height-reduction of 25 to 50% may occur; conse-

quently the volume of living matter would be reduced by an equivalent amount. A large tree-height is obtained because of systematic thinning of foliage and an avoidance of total canopy-closure in the highest levels of the forests, which in turn permits enough light to pass through to sustain all the vegetation below.

Our study has indicated a copious growth of surface roots in the Silent Valley forest. Jordan & Medina (1977), while describing the nutrient-conservation mechanisms in tropical rain-forests, point out that the root-mat and humus act as an exchange column (for quick absorption by roots) to prevent leaching of nutrients until the nutrients can be taken up by the roots. In this column, mycorrhizal Fungi play a role in the direct transfer of nutrients from decomposing litter to roots. This delicate mechanism would be vulnerable to flooding and water-logging—a condition which submergence by the proposed reservoir would create, owing to the expected rise in the water-table, at least around the shoreline.

In parts of the Silent Valley area, burning has led to replacement of the forest by coarse tussock-grasses (e.g. *Saccharum spontaneum*, *Imperata cylindrica*, *Themeda triandra*, etc.) with scattered dwarf individuals of *Emblia officinalis* and other fire-resistant tree species (Fig. 5). Man-induced fire is already 'eating away' the forests at the edges of the savanna, facilitating the spread of the latter, and approaching a situation whence it would be impossible to return to the level of original forest, even if it were given every opportunity to recover. The vegetation of cleared areas around Anghor in Cambodia, still does not fully resemble the surrounding areas of undisturbed tropical forests, even after a lapse of from five to six centuries (Dasmann *et al.*, 1974).

The alteration of vegetation by various biotic disturbances, including the total destruction of some habitats, would cause a reduction in plant diversity. Even the mildly-disturbed Attapadi forest has become less mesic than formerly and relatively species-poor, while the burnt sites have lost all their forest species. We have seen from the data on population structure of trees in the Silent Valley, that a remarkably high species-richness is made possible, in part, by the species-combinations varying from one girth-class to another. Thus species populations are in constant flux in space and time, and this is made possible when suitable habitats of sufficient sizes are available to encompass all the stages of growth of all the species.

Any serious reduction in the size and heterogeneity of the habitats involved is likely to lead to some disappearance of plant species, to which in turn may be related the survival of heterotrophic species. Many of the species of tropical rain-forests have not yet been catalogued, quite apart from gathering information about their life-cycles, physiology, population dynamics, economic uses, etc. Myers (1979) reports that only about one-sixth of the estimated three million organisms of tropical rain-forests have been catalogued, and the situation may not be very different in the Silent Valley forest.

Thus some preliminary observations by the Zoological Survey of India, involving some casual samples from the Silent Valley forest, indicate the presence of about 8,000 species, many of which are endemic, rare, undes-

cribed, or threatened (Swaminathan, 1983). Of the identified ones, 500 species belong to amphibia alone, some of them are caecilians or limbless amphibia, and the occurrence of primitive amphibians particularly of the genus *Malarophidium* is of special interest. A number of reptiles are new additions to the present catalogue of reptiles. Avian fauna is particularly rich. Among the mammals, the endangered Lion-tailed Macaque (*Macaca silenus*) is of particular interest.

Needless to say, the fate of a rich fauna depends on rich vegetation. According to Gilbert (1980), the loss of a 'keystone mutualist' (keystone mutualists are those organisms, typically plants, which provide critical support to large complexes of 'mobile links', the latter being those animals which are significant factors in the persistence of several plant species that in turn support otherwise separate food-webs) would, with some time-delay, cause a loss of mobile links followed by losses of link-dependent plants through a breakdown in reproduction and dispersion.

In fragmented habitats or in isolated stretches, certain plant species might be lost during the habitat disturbance, and certain species that are critical to canopy plants may die off as commuting distances between diverse resources become too great. According to Gilbert (1980), among tropical birds, fruit- and flower-feeders are known to be extinction-prone—presumably because the area required to assure the continuous availability of such resources is much greater than that required for the continuous availability of insect food. The local extinction-rates appear to be very high for tropical species (Stehli *et al.*, 1969; Farnworth & Golley, 1974), and therefore much more caution is needed with them than with species of other regions.

#### PLEA FOR A BIOSPHERE RESERVE

The construction of the proposed dam and reservoir in Silent Valley would fragment the continuity of the habitat by creating a physical barrier. The remarkably high rate of destruction of forests is resulting in a shrinkage in the area of natural ecosystems, which begin to exhibit 'island' characteristics. Experience from Barro Colorado Island in Panama indicates a gradual loss of species, with fragmentation and reduction of the size of the overall habitat (Foster, 1980; Gilbert, 1980). Consequently it is emphasized that, in order to protect the biological diversity of an area, it should be as large as possible, so as to include both elevational and micro-habitat differences (Eisenberg, 1980), and to satisfy the minimum-area requirements of the inhabiting species (Wilson & Willis, 1975). Take the example of wild elephants. An Indian Elephant (*Elephas maximus*) eats 2.5 quintals of vegetal material per day, and destroys many times more (Medway, 1969). In order to preserve the Elephant population and yet keep the forest loss at replaceable level, it is necessary that a sufficient area of forest is preserved.

The minimum critical size of an isolated tropical rain-forest, i.e. the area necessary to maintain a tropical forest community at close to its characteristic density (Lovejoy & Oren, 1981), is difficult to assess. However,

the low population-densities of most species, occurrence of dioecy in some, graduated instead of all-or-nothing flowering response, and the high degree of endemism, dictate that the forest area to be conserved must be very substantial (Ng, 1983).

A minimum of 200 mature individuals per tree species has been suggested by Ashton (1976) as an adequate breeding population. On average, across the three stands of the Silent Valley forest, the extrapolated species number was about 60 per 0.4 ha. In small sampling-areas of 0.18 ha we sampled 40 species. Following the criterion of Ashton (1976) for trees, a minimum of 2.5–7.0 ha for the three most important species, 10 ha for the next ten important species, 20 ha for the next five important species, 30 ha for the next 6 important species, and 60 ha for the next 7 important species, would be required. Needless to say, the remaining species would be far rarer, so that a correspondingly much larger area would be required to have 200 mature individuals of each of them.

It is obvious, however, that these calculations cannot be reliable—because, firstly, we sampled a very small area, and, secondly, numerical representation of a species cannot be assumed to increase proportionately with area, even though the total number of trees, regardless of the species, may do so. Data on the number of mature individuals of each species over a much larger area (23 ha) are available from Poore (1968) for the lowland forest in Jengka Forest Reserve, Malaysia: of the 377 species, 153 or 38% were represented by only a single mature individual each. It was calculated that, for each of these 143 rare species, every additional 23 ha would add one more mature individual, and a total of 4,600 ha would be necessary to meet the minimum standard of 200 mature individuals per species!

However, recent findings of Lovejoy *et al.* (1983) indicate that even the species which are included within the isolated reserved forest are exposed to various hazards and may vanish in the long term. These authors have been trying to assess the impact of fragmentation on the ecological dynamics of tropical rain-forest in Amazonia. The results gathered so far indicate that, even in only the first 19 months of isolation, the number of wind-thrown trees on the windward margin of a 10-ha isolated reserve increased considerably, and consequently species-composition changed; the number of standing dead trees (from sources other than wind) jumped dramatically from 9 to 65; an adult *Scleronema micranthum* (Bombacaceae) located on the windward margin of an isolated one-ha reserve flowered 6 months out of synchrony with other members of this species in intact forest, and survival of its seedlings was reduced conspicuously because of the high percentage of seed predation; a pair of fruit-eating monkeys confined to the 10-ha reserve started eating less-preferred green fruits and destroyed the seed-crop in the process; a Sakimoney (*Chiropotes* sp.) ruined the seed-crop of the only tree in fruit at one point and disappeared, presumably having perished; and so we go on.

The foregoing indicates that the reserves of tropical rain-forests cannot be maintained in the form of isolated stands; they need to be of large size if anything like their entire dynamics and diversity are to be maintained.

The recent impetus on the construction of hydro-electric projects and other land-uses in the Western Ghats is continually fragmenting the long stretch of tropical rain-forest habitat (Fig. 12, cf. Nair *et al.*, 1980). The question is not so much whether or not this fragmentation should be allowed to continue unabated, but how to stop it. We feel that the short-term economic gains would look very meagre in quality and quantity if compared with the long-term gain that could only come through preserving this unique gene-reservoir. In the words of Dasmann *et al.* (1974), 'the biotic diversity is of inestimable value to mankind for scientific, educational, and aesthetic purposes—a value which is bound to be enhanced with the passage of time, as such resources become more restricted.' It is clearly most desirable that not only the Silent Valley but also the adjoining, unspoilt natural areas, should be included in some such conservational body as a Biosphere Reserve (about 39,000 ha, cf. Swaminathan, 1983), *inter alia* to preserve their high level of genetic diversity. Being relatively inaccessible (N.C. Nair, pers. commun.), the Silent Valley should make the heart of any such Biosphere Reserve.

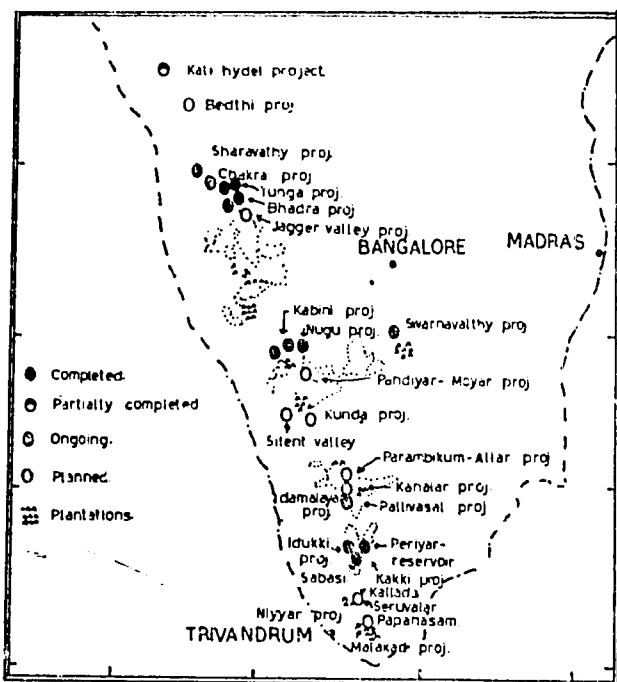


FIG. 12. Sketch-map indicating fragmentation of the tropical rain-forest habitat of Western Ghats due to hydro-projects and plantations (from Nair *et al.*, 1980). Scale indicated by distance from Bangalore to Madras = ca 300 km.

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#### SUMMARY

Most of the features that are commonly attributed to typical tropical rain-forests, such as a preponderance of woody vegetation and species with leaves in the mesophyll size-class, tall slender trees with 'flying buttress' and unusually thin bark, multilayering of vegetation with abundance of epiphytes and stranglers, evergreenness, strong tendency to change in species composition in time and space, and high diversity of dominance, are plentifully displayed by the forests of the Silent Valley in southwestern India. A relatively high species-richness, remarkably thin bark of trees, and high total tree-basal area, indicate that the valley embodies a virgin forest and that conditions for growth are very favourable. Because of the terrain, heterogeneity in habitats is well marked.

The proposed construction of a dam and large flooding reservoir threatens to bring about several undesirable alterations in the environment of the Silent Valley rain- and riparian forests, and the disturbances that would follow such construction and flooding would be highly detrimental to the diversity of the forests and to the complexity of their structure. Hence a plea is made for the setting aside forthwith of a proposed major 'Silent Valley Biosphere Reserve', which could safeguard a unique part of the world's genetical heritage and one of its most interesting complexes of natural ecosystems.

#### Silent Valley as a World Heritage Site?

Recent press reports having carried such alarms as The Times of India News Service's one of 29 July 1984 that 'Some opposition parties in Kerala, including the CPM, have launched a campaign for revival of the Silent Valley hydel project that had been dropped in the face of protests by environmentalists', we feel that the best way to preserve and safeguard this unique area for posterity might still be its declaration as a World Heritage Site—as suggested by Dr G.M. Oza in *Environmental Conservation*, 8(1), p. 52, Spring 1981, and recalling the recent saving of the SW Tasmanian Wilderness as reported in our last Winter's issue (pp. 355-6) by Drs Saddler & Dragun.—Ed.

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